HATCHERY COMMENTS

Introduction

Since the ESA salmon process began in 1990, the tribes have repeatedly made recommendations for production and other related actions in numerous fora including: the ESA listing process, the Salmon Summit, the NPPC Fish and Wildlife Program amendment process, various NMFS recovery planning processes, various section 7 consultation processes, Pacific Salmon Treaty negotiations and U.S. v. Oregon negotiations. The tribes developed *Wy-Kan-Ush-Mi Wa-Kish-Wit* to provide a framework for restoration of Columbia basin salmon. NMFS has repeatedly ignored the tribes' recommendations.

NMFS policy does not count hatchery reared supplementation fish as wild fish upon their return 4-5 years in the future. The offspring of the returning supplementation fish would be considered as wild fish and would be listed. The offspring would return as adults in another 4-5 years (total of 8-10 years from initial supplementation action). The tribes believe that NMFS should recognize the adult returns of out-planted juvenile salmon as contributing to the success of salmon recovery. NMFS refuses to do so. Instead, NMFS will wait another 4-5 years when the progeny of this fish return to recognize their contribution to conservation.

Summary of Comments

1. Because the BiOp uses primarily draft documents to support its conclusions, it is unclear how changes in these draft documents affect the BiOp? In addition, the BiOp uses many poorly defined terms that make interpretation difficult. For example, the use of the term “recovery” in the BiOp should likely be replaced by the term de-listing. The use of the term recovery in this context is dangerous, because the actions needed to reach de-listing goals, are far less than required to rebuild the runs to harvestable levels and fairly share the conservation burden, which is the tribes' view of recovery. Therefore, it is important that the correct terminology is applied in the BiOp.

2. The BiOp does not include a schedule for mitigation. In other words, the risks of extinction and the probabilities for recovery listed in the BiOp are calculated under the assumption that management actions (such as habitat repair) will be completed immediately, and that the beneficial effects of those actions will immediately boost survival. This assumption is obviously incorrect, hatcheries (for example) take years to build, and it often requires several generations of production to result in a substantial gain in abundance. Therefore, in reality, the risk of extinction is higher, and the probability of recovery is lower, than the estimates presented in the RPA.

3. In addition to assuming that survival boosts will be immediately realized, the RPA also assumes that hatchery-reared fish have had zero spawning success in

natural conditions. In other words, all natural production is assumed to be the result of “wild” fish, not spawning by hatchery-origin adults. Because this assumption is likely false, the BiOp inflates estimates of productivity by naturally spawning stocks. These two assumptions, in all likelihood, result in a serious underestimation of the risk of extinction, and overestimate the probability of recovery. The result is that the actions necessary to achieve the goals listed in the RPA will be unlikely to achieve the required outcome. The RPA does not address many stocks that are currently in peril. For example, no conservation hatchery actions are listed for chinook salmon in the Middle Fork Salmon River, among others.

4. The RPA requires that hatcheries derive broodstock from local stocks, and cease using composite stocks and/or stock transfers, the RPA fails to address two major points:
- How will composite stocks, such as Carson spring chinook salmon be utilized?
- For some production programs intended to augment harvest, collection of local broodstock could result in an increased rate of population decline among the naturally spawning stock, particularly if natural spawners are not replaced in-kind by hatchery production.

5. The BiOp alludes that all hatchery-reared fish must be marked in order to perform run reconstruction. This is not the case.

6. The RPA, while recognizing the benefits of conservation hatcheries, suggests that these programs should be withheld as “long as is prudent”. This could be a very wasteful and destructive strategy, since hatchery intervention must necessarily be more intrusive as population size decreases.

7. Finally, and perhaps most importantly, the RPA requires only the minimum possible mitigation to avoid jeopardy. Given the poor assumptions included in the calculation of the goals, it is highly unlikely that the RPA will realistically avoid jeopardy, much less lead to rebuilding.

8. We recommend that NMFS adopt the adult out-planting protocol described in these comments for use of “surplus” returning adult salmon to hatcheries.

Review of the 2000 RPA for Hatchery Programs

This review is intended to provide scientific critique and guidance regarding hatchery actions as they relate to the Reasonable and Prudent Alternative (RPA) presented in the 2000 Biological Opinion on the Federal Columbia River Power System (BiOp). The review consists of three sections. The first section provides commentary and guidance relating to the RPA as proposed, organized by specific chapter headings. The second section provides commentary and guidance relating to the All-H Update (NMFS 2000) as it applies to the RPA. The third section provides commentary and guidance relating to the Artificial Production Review as referenced within the RPA and All-H paper.

It should be noted that this review was substantially hindered by the fact that the 2000 Biological Opinion on the Federal Columbia River Power System (NMFS 2000), itself a draft document, cites as scientific support many previous draft documents produced by the NMFS. Examples include; the "All-H" draft and update, A Standardized Quantitative Analysis of Risks Faced by Salmonids in the Columbia River Basin (McClure *et al.* 2000), various Cumulative Risk Initiative (CRI) documents, and UCR Steelhead and Spring Chinook Salmon Population Structure and Biological Requirements (Ford *et al*. 1999). It is unclear how changes in the draft documents used for scientific support will be incorporated and accounted for in the BiOp and associated RPA.

Absolute Extinction

Because NMFS is changing the jeopardy standard, by using the concept of "absolute extinction" (one adult return per generation) as the survival metric, we suggest that the paper would benefit from a discussion of the genetic and demographic risks faced by populations at much higher levels (i.e., functional vs. absolute extinction).

Interim Recovery Metrics (Abundance)

We suggest that the interim recovery metrics should be re-labeled as "interim de-listing metrics". The tribes view recovery as the establishment of naturally self-sustaining populations of salmon, throughout the majority of their historical range and exhibiting a variety of life histories, at abundances supporting meaningful treaty fisheries at all usual and accustomed fishing places.

Effectiveness of Hatchery-Reared Adults

Throughout the Hydro BiOp, the probability of extinction and achieving recovery goals is linked to the spawning effectiveness of hatchery-reared adults. As spawning effectiveness of the hatchery-reared adults increases, the probability of extinction increases, and the probability of recovery decreases. The mechanism behind this relationship, however is not described. This relationship is described in McClure (2000), which explains that this "*is not due to any negative ecological or genetic effect of hatchery fish, but arises as an accounting effect, simply because the parent pool is much larger*". This accounting problem should be described in the BiOp to prevent confusion regarding the effects of hatchery-reared fish. As presented in the BiOp, this relationship is open to misinterpretation as evidence of detrimental effects of hatcheries, when this is simply not what is intended in McClure (2000).

The reproductive success of hatchery-reared fish from certain programs is reasonably well documented. For example, the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) have successfully re-established a naturally reproducing spring Chinook run using Carson stock spring Chinook. CRITFC has provided NMFS with numerous examples of successful hatchery programs that NMFS has failed to incorporate.

Hatchery Misrepresentation

The BiOp contains many misrepresentations regarding the use of hatcheries in the Columbia Basin. These discrepancies are discussed in the following paragraphs.

Section 5.3.3, paragraph 2. "Hatcheries have traditionally focused on providing fish for harvest, with less attention to identifying and resolving factors causing declines of native runs". This sentence contains two major logic flaws. First, hatcheries in and of themselves, rarely have the ability to address the factors leading to the decline of the endemic stocks they augment. For example, a hatchery cannot fix hydrosystem mortality. Second, the use of the term "native" in this context is incorrect, it appears that NMFS intended to use the term "local," as in hatcheries propagating a transferred stock are not using the "local" stock. The misuse of the term "native" is present throughout much of this section.

Section 5.3.3, paragraph 4. There is no reason to believe *a priori* that hatchery fish are inbred. In fact, many of the hatchery-propagated stocks throughout the Columbia Basin are outbred. Consider for example the Carson stock spring chinook, which was formed as a subsample of all upriver spring chinook salmon passing Bonneville Dam.

Section 9.6.4, paragraph 4. The BiOp states that conservation hatchery programs "have not yet ensured the long-term enhancement of self-sustaining populations…". This is a confusing statement. Conservation hatchery programs could likely enhance salmon populations *ad infinitum*, however the goal of most such programs is to promote natural reproduction in the absence of hatchery influence. This latter goal however is substantially hindered by a lack of concomitant action to remedy the root causes for the initial decline of the stock. In many, if not most, cases the factors resulting in the decline of the stock are not within the management influence of the agency(ies) running the propagation facilities. As such, until sources of mortality, such as the FCRPS, are meaningfully addressed, most conservation hatcheries will be unsuccessful at achieving the goal of naturally self-sustaining stocks.

Hatchery Reform Actions (Section 9.6.4.1)

While the hatchery reform actions listed in the RPA represent an improvement over some existing conventional hatchery management, there are several issues that require further development.

Bullet One: While the elimination of "inappropriate broodstocks" and replacement with local broodstocks sounds good, there are several issues that must be addressed if this action is pursued. For example, hatcheries whose sole purpose is to provide fish for harvest might be poor candidates for this type of reform. Collection of broodstock from an already declining naturally spawning population would be ill-advised, particularly if the goal of the program is simply to maintain a hatchery run for the purposes of harvest.

Simply stated, such an action would decrease abundance of the naturally spawning stock and presumably (as has happened in the past) fish collected from the naturally spawning population would not be replaced in kind with hatchery-reared adults. In this case, the result might simply be an increased rate of decline for the naturally spawning population as broodstock is collected.

Further, simply destroying "inappropriate broodstock" (which we assume refers to composite stocks, such as Carson spring chinook salmon) is not appropriate. Given that many of these composite stocks were formed when salmon were more abundant, there is the possibility that these composite stocks may harbor genetic variation that has been lost in the wild due to extinctions or decreased abundance. In addition, some recovery programs (such as reintroductions) might benefit from an outbred stock.

<u>Bullet Three:</u> We suggest that the bullet should include improved release protocols as well. For example, construction of semi-natural in-stream final acclimation facilities might be a useful mechanism to increase homing as well as increasing salmon distribution within a given watershed.

<u>Bullet Four:</u> The opportunity for hatchery reform provided by the RPA would be more beneficial if these "reformed" hatcheries were required to produce fish that were acceptable for use in increasing abundance of the naturally spawning stock. Given the reforms listed, why should there be a limit on the number of hatchery-reared adults that are allowed to spawn naturally? This is particularly troubling given that the RPA requires that local brood be collected. If hatchery-reared adults from these programs are not allowed to spawn in the wild, this will simply result in "mining" the natural stock, and will increase, rather than decrease the probability of extinction, or at best slow recovery.

<u>Bullet Seven:</u> We agree that marking hatchery-reared fish for monitoring and evaluation purposes and run reconstruction is an important tool, which can be useful to address specific scientific questions, however we do not agree that 100% of hatchery-reared fish should be marked. Further, mutilation (i.e., removal of the adipose or other fins) has been shown to be detrimental to salmon, therefore we expect that the NMFS will consider other types of marking methodology as appropriate. Further, since marked fish are available to selective fisheries, it would be counter-productive for some programs (*e.g.*, Conservation programs) to mark their progeny.

9.6.4.2 Safety-Net Hatchery Actions/Reform of Existing Hatcheries

Given that the Reasonable and Prudent Alternative (RPA) forwarded by the NMFS relies on uncertain benefits from transportation for short-term boosts in survival coupled with long-term survival benefits from habitat actions, we suggest that the "safety-net" hatchery actions as proposed are insufficient to maintain, much less increase, the abundance of several already depleted and declining stocks of salmonids. At a minimum, should the NMFS seek to implement the RPA, we suggest that additional hatchery actions must be considered for several stocks (*e.g.*, stocks in the Middle Fork Salmon River). In addition, the RPA makes no mention of reintroduction programs for stocks that are currently believed to be extinct, for which ample habitat is available (*e.g.*, Snake River coho salmon).

The last paragraph of section 9.6.4.2 contains three criteria intended to guide implementation of safety net hatchery programs. The first two criteria are agreeable, however the third criterion suggests that the NMFS has the ability to determine which and how many populations within an ESU will be necessary for recovery. We suggest that **all** remaining populations are necessary for recovery, and to consciously allow the extinction of any population is unacceptable. To allow further declines in the diversity of life-history strategies, genetic variability, and geographic distribution would be taking a step backward in the recovery of salmonids. Further, given that salmonids are widely believed to exist as metapopulations, we suggest that the NMFS simply does not have adequate data to determine which and how many stocks are necessary for sustainable natural production (Cooper and Mangel 1998).

Section 9.6.5.2
Action Item One: As CRITFC has commented on several occasions, the VSP document, in its current form, provides very little quantitative guidance useful in determining population status. Our comments on the VSP document are herein incorporated by reference.

Section 9.6.5.2, second bulleted section
The last paragraph of section 9.6.5.2 suggests that since safety-net hatchery programs are not the NMFS preferred option, they will be "withheld as long as prudent". What precisely are the criteria for determining when action is "prudent"? We suggest that waiting for a substantial decline in abundance is not appropriate, simply because at lower abundances hatchery actions are necessarily more intrusive (e.g., captive broodstock), and less likely to be successful. Further, why delay action until the last few fish when presumably much of the genetic variation represented in the stock(s) has already been lost? We suggest that adequate data exist to determine whether populations are declining, and these data should be used to aim management actions at stocks before further declines decrease the probability of program success and contribute to the loss of genetic and life-history diversity.

Section 9.6.5.4, paragraph 5.
Following the bulleted list of RM&E goals, the NMFS suggest that "It is important to note that it will be possible to evaluate the effects of mixed stock populations only when hatchery marking practices become comprehensive". If the NMFS intend to require that every hatchery fish should be marked, this statement is untrue and misleading. Given the reforms suggested (i.e., replacement of composite broodstock with local broodstock), where would these mixed stocks exist? In a limited number of cases it may be beneficial to mark a proportion of hatchery-reared fish, however in many cases this is simply unnecessary. Is the NMFS aware of the substantial literature documenting the negative effects of marking? Given the deleterious effects of marking with respect to survival and homing, we suggest that requiring every hatchery-reared fish to be marked is ill advised, and counter-productive (see following references and citations therein).

Habicht, C., S. Sharr, D. Evans, and J.E. Seeb. 1998. Coded wire tag placement affects homing ability of pink salmon. Transactions of the American Fisheries Society. 127: 652-657.

Nicola, S.J. and A.J. Cordone. 1973. Effects of fin removal on survival and growth of rainbow trout (*Salmo gairdneri*) in a natural environment. Transactions of the American Fisheries Society. 4: 753-758.

Phinney, D.E. and S.B. Matthews. 1969. Field test of fluorescent pigment marking and finclipping of coho salmon. Journal Fisheries Research board of Canada. 26(6): 1619-1624.

Weber, D. and R.J. Wahle. 1969. Effect of finclipping on survival of sockeye salmon (*Oncorhynchus nerka*). Journal Fisheries Research Board of Canada. 26(5): 1263-1270.

Section 9.7.2.1.2.

The survival increase expected to result from the RPA is insufficient for the majority of the listed stocks, even given the restrictive and highly unlikely assumptions (*e.g.*, that hatchery-reared fish do not contribute to natural reproduction) that are required to achieve the best-case scenarios. Further, the goal of the RPA should not be to enact the minimum change necessary to achieve the survival and recovery metrics, given the stochasticity associated with all life-stages of salmon (and the environment), we suggest that the RPA should require changes that far exceed the minimum necessary to achieve the survival and recovery metrics. Perhaps the RPA should require the changes necessary to ensure that survival and recovery metrics are achieved assuming the worst-case scenario. This is particularly relevant given that a schedule for attainment of the mitigation activities is not included. This fact suggests that the risk of extinction is much greater than addressed by this document.

Section 9.7.2.2.2

See comments regarding section 9.7.2.1.2.

Section 9.7.2.4.3

See comments regarding section 9.7.2.1.2.

Section 9.7.2.5.3

See comments regarding section 9.7.2.1.2.

Table 9.7-16.

The table repeatedly includes a survival benefit for wild fish derived from decreased negative interactions between naturally spawned and hatchery-reared juveniles. Given that negative interactions between naturally spawned and hatchery-reared juveniles have not been documented for the bulk of the stocks in question, we suggest that it is inappropriate to assume that minimizing interaction will increase survival. It is simply inappropriate to assume that a survival benefit can be accrued by addressing a potential problem that is not documented or quantified.

Update of the All-H Paper

Section 3.5.1 Performance Standards

We suggest that performance standard two would benefit from the inclusion of more adaptive mechanisms. Not only is a 5% stray rate arbitrary, but also in certain circumstances enforcement of this policy could be counter-productive. Given that the NMFS best estimate of natural homing rates is 90% plus or minus 10% (NOAA 1997), it seems that 5% is overly restrictive. In addition documented stray rates range from 0-100% (for examples see Quinn 1993 and NOAA 1997), suggesting that natural stray rates are highly variable; therefore we recommend that stray rates be reviewed on a case-by-case basis. Further, it is possible that enforcement of this policy could penalize successful programs. Finally, how will stray rates be estimated? If stray rates are estimated simply from coded wire tag recovery of captured adults, it is impossible to know whether those adults would have spawned in the non-natal location, or whether they were simply captured while "holding" in the tributary.

We recommend that performance standard three could benefit from more specificity. We agree that marking hatchery-reared fish can be a useful tool to address specific management questions, however we do not agree that all hatchery-reared fish should be marked, and we will not support "mass-marking," particularly if it is pursued simply as a policy exercise.

Outplanting Adult "Surplus" Hatchery Returns

We recommend that hatchery-reared adults or progeny be used to augment natural production. Others have raised concerns about this action, which concerns appear to stem from fears that hatchery-reared adults/progeny are inferior to their wild counterparts, and that interbreeding may reduce the fitness of the overall population. This section of our comments addresses those concerns and suggests a specific scientific protocol to implement to address those concerns. We recommend that NMFS adopt this protocol in the All H Paper.

Several studies suggest that relaxation of natural selection in hatcheries, or selection for the hatchery environment (artificial selection), reduce the performance of hatchery-reared fish in the wild. Changes in phenotypic (Fleming and Gross 1990), genetic (Bartley and Gall 1990), and behavioral characteristics (Doyle and Talbot 1986, Berejikian 1995) within hatchery-reared stocks have been documented. However, we lack conclusive evidence to suggest that these differences are manifest in the progeny of hatchery-reared adults that reproduce in the wild, or that the observed differences resulted solely from hatchery stock development.

Despite the lack of conclusive evidence that hatchery-reared adults/progeny are inferior to their wild counterparts, the potential exists for life-history or behavioral incompatibility between a naturally spawning stock and the "surplus" adults that are predicted to return to many Columbia basin facilities. If, for any reason, the hatchery-reared adults are incompatible with a naturally spawning stock, their presence could either be deleterious to the naturally spawning population, or have no effect at all (if for example hatchery-reared adults suffer high mortality). Since it is difficult *a priori* to determine the suitability of surplus adults for natural spawning, we recommend that augmentation of naturally spawning populations should occur through adult outplants, rather than outplants of progeny derived from the surplus adults. Adult outplants may be superior to other life history stages for the following reasons:

1. Outplanted adults would be "required" to prove their suitability for augmentation of the naturally spawning stock. For example, outplanted adults would be required to find and compete for mates, locate and defend appropriate spawning habitat, and excavate redds or fertilize eggs.

2. The progeny of hatchery/hatchery or hatchery/natural matings would be required to return as adults and spawn to have a lasting demographic and genetic impact on the stock.

3. Hatchery-reared adults could be placed above weirs and isolated from natural spawners. The reproductive success of hatchery-reared adults could then be estimated by smolt trapping below the weir. These data would directly address many of the critical uncertainties regarding the use of hatchery-reared adults/progeny to affect recovery.

Simply stated, if hatchery-reared adults can spawn successfully, and their progeny return at a similar rate to naturally spawned progeny, we suggest that the hatchery-reared adults are useful for recovery.

Alternatively, surplus adult returns could simply be left in the river to spawn or perish of their own accord. In fact, allowing surplus hatchery-reared adults and naturally spawned adults to establish their own population boundaries may be preferable to management intervention in some circumstances (Templeton 1986). Unfortunately, the effectiveness of this alternative would be far more difficult to assess, since the ultimate destination and reproductive success of hatchery-reared adults would be difficult to estimate. Should this option be pursued, a subsample of surplus adults could be implanted with radio transmitters at the hatchery, and released back to the river. Relocations of telemetered adults could be useful in describing the behavior and destination of surplus adults, in addition to allowing rough enumeration of the number of surplus adults migrating to a given tributary.

Criteria for use of surplus adults for augmentation

We suggest that many of the putatively deleterious effects of outplanting hatchery-reared adults can be ameliorated through enforcement of a few guidelines. These criteria, discussed in detail below are; history of stocking, life-history compatibility, probability of disease transmission, and status of the proposed target stock. In addition, the number of salmon required to re-establish or maintain ecosystem functions should be considered, as well as the quality of the habitat into which surplus adults will be outplanted.

History of stocking

Naturally spawning populations that have been previously augmented with progeny from a hatchery expecting a surplus adult return, may be better candidates for augmentation than naturally spawning populations with no history of hatchery influence. Similarly, if a naturally spawning population served as a source of broodstock for a hatchery, augmentation using adults from that hatchery would be unlikely to be detrimental. In either case, the extant naturally spawning population likely shares genetic and/or life-history traits in common with the hatchery-reared progeny/adults either due to previous introgression, or because the hatchery stock was derived from the naturally spawning stock.

Life-history compatibility

The timing of adult migration and spawning, juvenile emergence, and smolt emigration are critical factors contributing to, or limiting the survival of salmon (Groot and Margolis 1991). Assuming that the naturally spawning stock exhibits life-history traits that are optimal under current environmental conditions, deviation in these traits from the naturally-spawning stock may decrease the effectiveness of hatchery outplants (Nickelson *et al*. 1986). Therefore, if the return of surplus adults does not correspond to the adult migration timing exhibited by the naturally-spawning stock, the naturally-spawning population probably is not an ideal candidate for augmentation. The same "rule of thumb" applies to juvenile emergence and emigration timing as well, although these may be difficult to assess given the control exerted over these traits in the hatchery environment.

Probability of disease transmission

Before surplus adults are outplanted, the probability of disease transmission to the naturally spawning stock should be qualitatively assessed. If a disease is more prevalent within the hatchery than among the naturally spawning stocks that are candidates for augmentation, hatchery-reared adults may constitute a disease vector, and hence negatively impact the naturally spawning stock. Prior to outplanting, we suggest that a subsample of adults intended for augmentation be assayed for the presence of common diseases. If a disease is detected, and there is reason to believe that prevalence is higher among the hatchery-reared adults, augmentation may be inadvisable.

The process of handling and hauling adults under crowded conditions may exacerbate diseases present in the hatchery environment. Therefore, augmenting streams closer to the hatchery source may be less risky than augmenting distant streams.

Status of the naturally spawning stock

Regardless of genetic (dis)similarity between the target and donor stock, augmentation should be considered if the naturally-spawning stock is at demographic risk, or is present in numbers that suggest that a substantial loss of genetic variability may have occurred.

Unfortunately, for many naturally spawning stocks, the information necessary to determine the degree of genetic or demographic risk may be unavailable. The effective number of breeders (N_b) may be a useful measure to assess demographic and genetic risk for salmonid populations. Simply stated, N_b is the number of adults that spawn successfully in a given year, and pass genetic material to the next generation, after taking into account variation in reproductive success, unequal sex ratio, and overlapping generations, among other considerations. N_b is typically some fraction of the total number of adults returning in a single year to spawn (census size; N).

The degree to which N_b is less than N, is population specific, and is likely controlled by environmental stochasticity, and population size. For example, in smaller populations the probability of inbreeding increases, since the adults returning to that location may be the offspring from a limited number of families. Similarly, in a highly stochastic environment, variation in reproductive success may increase. For example, redds may be destroyed indiscriminately by flood events. In this case the adults returning in a given year may also be the progeny from a limited number of families, since the redds of other families have been destroyed. In either case, random losses of genetic variation would be accelerated.

Empirical studies suggest that the degree to which Nb is less than N (N_b/N ratio), typically ranges between 0.1 to 0.33 (Hedrick and Hedgecock 1994). These estimates may be useful in placing bounds on the degree to which a naturally spawning population may be at genetic or demographic risk. As discussed above, as population size decreases or environmental stochasticity increases, the N_b/N ratio likely decreases as a result of inbreeding or increased variance in reproductive success. As the N_b/N ratio of a stock decreases, the risk of losing genetic variation increases. Since this is largely a function of demographic factors such as variance in reproductive success, it is likely that the stock is also at demographic risk.

The degree of genetic/demographic risk can be roughly estimated as the upper and lower bound described by N* N_b/N. If a stock specific estimate of N_b/N is unavailable, the number of adults returning in a given year can be multiplied by the N_b/N ratios empirically observed in salmon populations. For example, if 100 adults return in a given year, a rough estimate of N_b can be derived by 100*0.1, and 100*0.3. That is, N_b probably ranges from 10 to 33.

Since the ability to maintain local adaptation, or to maintain adaptive potential in a stochastic environment is linked to genetic variability, it follows that the ability to maintain genetic variation is critical. As N_b decreases, or as the N_b/N ratio decreases, the probability of maintaining genetic variation likewise decreases. The probability of maintaining genetic variation is often displayed as the probability of maintaining a rare allele over one generation, which is a simple binomial function (modified from Kincaid 1997):

$$\mathbf{P_R=1-(1.0-p)^{8N_b}}$$

Where:

P_R is the probability of rare allele retention for one generation
p is the frequency of a rare allele (typically defined as p=0.01)
N_b is the effective number of breeders, while the prefix is twice the average generation length (in this case 4*2=8, the most common case for spring chinook)

Using the equation described above, a stock of spring chinook in which 100 adults return (N=100), with an N_b between 10 and 33 (as presented previously), would have a 55% to 93% probability of maintaining a rare allele over one generation (four years). This rate of rare allele retention is lower than guidelines published in conservation literature, which suggest that the probability of rare allele retention should be no less than 95% per generation (Allendorf and Ryman 1987). Using the same equation, an N_b of roughly 38 is necessary to maintain a 95% probability of rare allele retention for one generation, which corresponds to a total adult return between 160 to 380 adults.

We suggest that augmentation should be considered for spring chinook stocks with an adult return below 160, particularly stocks that have a history of escapement below this level. Simply stated, these populations are likely candidates for genetic and demographic risks, and augmentation may serve to counteract depensation, minimize the loss of rare genetic variation, and provide an infusion of genetic variation that may aid in adaptive response to a stochastic environment.

Advancing this logic provides an estimate for the minimum number of adults that should be outplanted. For example, 380 total adults is a conservative estimate of the minimum number necessary to maintain a genetically stable stock. Therefore, wherever augmentation is pursued, managers should consider outplanting enough surplus adults to result in a combined (hatchery-reared + naturally spawned) stock of at least 380 adults.

Ecosystem requirements

It should be noted that 380 adults (derived above) is a conservative minimum stock size, this number is based solely on the probability of maintaining genetic variation, and buffering demographic risk, however this number may be far too low to stimulate other ecosystem functions. Therefore, when considering the absolute number of salmon to be outplanted, mangers should consider re-establishment of ecosystem functions.

The presence of salmon effects terrestrial and aquatic ecosystem functionality both directly and indirectly. Construction of redds promotes gravel recruitment, and may change the dimensions and stability of a streambed or channel (NRC 1996). For example, redd construction along the banks of a stream may widen the channel, which would decrease erosion and scouring during flood events, hence providing a stable environment for aquatic biota (NRC 1996). In addition, restoring salmonid populations may be directly beneficial to other species by providing a pathway for recruitment of marine nutrients, or as a source of prey. Recruitment of marine nutrients is expected to play an important role in estuarine food webs (Fujiwara and Highsmith 1997), freshwater and riparian vegetative growth, and the growth of periphyton (NRC 1999). Avian predators, marine and terrestrial mammals, and insects among other biota may benefit from live and dead salmonids (Hewson 1995, NRC 1996).

Obviously, salmon play a variety of important roles in Pacific Northwest ecosystems, however the absolute number of adults necessary to stimulate these functions is unknown. The following questions are intended to indicate whether these functions could be important in a given stream:

1. Are there other species present whose habitat and nutrient needs are, or were historically, provided by salmon?

2. Would increasing the abundance of adult salmon increase carrying capacity for future generations?

The importance of these questions can be gauged by the relationship between salmon and the species in question:

1. *Strong, Consistent Relationship*. Many wildlife species have a strong, consistent relationship with salmon (or did so historically), which regulated their distribution, viability, and abundance. Salmon supports(ed) these species, especially at particular life-history stages or during specific seasons (some piscivorous birds, predatory fish, bear, etc.). These are species with a direct (e.g. feeds on salmon, or salmon eggs) and routine relationship.

2. *Recurrent Relationship.* The relationship between salmon and this species is characterized as occasional but routine and may be localized within a watershed. The percent of salmon in the diet may vary from 5% to 50%, depending upon location and time of year.

3. *Indirect Relationship.* Salmon play an important role, but have an indirect link to many species. For example, secondary consumers of salmon, such as insects that feed on salmon carcasses may themselves serve as a prey item for salmon and other species. The loss of salmon carcasses may limit nutrient cycling and sever links to insects and other wildlife. This indirect pathway is a major source of nutrients for early life history stages of salmon, thus, the carrying capacity of the environment for salmon may be controlled to a large extent by the number of returning salmon in the previous generation.

4. *Rare relationship*. Some species utilize salmon rarely, often a little as 1%. For these species, salmon are generally utilized when a disturbance reduces the abundance of alternate forage. There may be times when salmon can play a critical role in sustaining these populations.

Habitat Quality

In addition to augmenting existing salmon stocks, surplus hatchery-reared adults may be used to populate waters that do not currently support a stock. However, if this alternative is pursued, the quality of the habitat must be critically assessed. If the habitat is unoccupied because it is unfit for salmon, outplanting surplus adults will likely be unsuccessful. In other words, if salmon were extirpated, and the factors resulting in the extirpation have not been addressed, there is no reason to believe *a priori* that surplus adults will stimulate the re-establishment of a stock. The following examples, though not exhaustive, may provide some guidance for outplanting adults in currently uninhabited waters:

1. Tributaries of the Snake River and upper-Columbia that historically supported salmon stocks may be appropriate locations for surplus adult outplants. Monitoring the adult return rate exhibited by these outplants could be useful in defining the level of management effort necessary to re-establish stocks in these tributaries, or to define the factors limiting natural reproduction.

2. Locations that have suffered local extinctions due to habitat alteration, such as siltation resulting from logging activities, may be appropriate for surplus adult outplants if habitat restoration has occurred. In this case, the reproductive success of hatchery-reared adults could be used as a measure to assess the benefit/success of a given habitat restoration action.

3. Locations that were historically inaccessible as a result of passage barriers, which now have adequate passage, may be appropriate locations for surplus adult outplants.

We suggest that surplus hatchery-reared adults may be appropriately used to augment naturally spawning stocks meeting some or all of the criteria formulated above. In fact, outplanting surplus adults may benefit small, at risk stocks, by providing genetic variation, reducing depensation, and minimizing genetic drift. If surplus adults are not directly outplanted, managers could consider allowing surplus adults to locate spawning habitat without human intervention. In either case, we suggest that adult outplants are preferable to any other life-history stage, since adults would be required to locate and defend appropriate spawning habitat, and exhibit natural mating behavior in order to successfully reproduce. Given either alternative, we suggest that monitoring and evaluation be employed, if possible, to determine the reproductive success of outplanted adults. The information gained by such an experiment could prove useful in determining whether or not hatchery-reared fish may be useful for recovery. In addition, the appropriate use of surplus adults may provide a useful measure of the success of habitat restoration and barrier passage technologies. Finally, increasing the abundance of adult salmon may serve to re-establish ecosystem functions beneficial to many species inhabiting the Pacific Northwest.

Should comanagers choose to destroy surplus adults, or merely use them to augment sport fisheries, an opportunity to positively effect natural production, and address key uncertainties relating to the use of hatcheries in recovery will be irretrievably lost. In either case, the presence of surplus hatchery-reared adults should fuel a region-wide dialogue concerning hatchery management practices. Specifically, can a "surplus" exist sympatrically with stocks that are listed under the Endangered Species Act?

Artificial Production Review

The hatchery portion of the Draft Biological Opinion (NMFS 2000) and the All-H Paper suggest that the Artificial Production Review (APR, NWPPC 1999) be used as the basis for hatchery reforms and newly proposed artificial propagation programs within the Columbia basin. Therefore, it is appropriate that the CRITFC provide comments pertaining to the APR as it affects tribal programs. The following review provides comments on the APR proper, followed by a review of the performance standards and indicators.

APR Proper

Page 12, Conservation Hatcheries. Supplementation must be listed along with captive broodstock and cryopreservation as a means to maintain genetic and life-history characteristics of stocks in immediate peril of extinction.

Page 14, Bullet 4. This bullet suggests that non-native species may be introduced to areas no longer capable of maintaining native species. If by non-native species the authors are suggesting that species such as American shad be introduced, we cannot agree with this recommendation. A wealth of data exist which suggest that the introduction of non-native species is detrimental to ecosystem function.

Section IV., suggested guidelines in hatchery practices, guideline 12. Guideline 12 suggests that supplementation programs should avoid including strays in broodstock. We suggest that strays should be included in proportion to the rate observed in the naturally spawning component of the population being supplemented. Straying is a natural feature of the life-history of salmonids, deliberately limiting straying will artificially increase isolation. Given that straying is a useful mechanism for the maintenance and distribution of adaptive genetic variation (Slatkin1985, Cooper and Mangel 1999), and provides the means for creation of additive genetic variation (Wade and Goodnight 1998) this recommendation seems shortsighted.

APR: A Scientific Basis for Columbia River Production Programs

Section B, paragraph three. The document suggests that chinook, coho, and steelhead salmon are most often limited by the rearing capacity of streams they inhabit. We agree that under natural circumstances this may be the case, however we suggest that current productivity of many of these stocks is limited primarily by external factors, such as passage mortality.

Performance Standards and Indicators

At present, we suggest that the performance standards and associated indicators are, for the most part, inapplicable. Our conclusions are shared by the Independent Scientific Review Panel (ISRP), which suggested that "it is unclear how the current standards are to be used, in general or at the level of an individual hatchery" (ISRP 2000). We suggest that the NMFS in collaboration with the tribes and other co-managers formulate more widely applicable and understandable artificial propagation standards.

In the following paragraphs, we review each standard and associated indicators using the criteria presented in the APR (NWPPC 1999); measurable, realistic, feasible, clear and understandable, affordable, and consistent application in policy and law. NWPPC (1999) performance standards and associated indicators are presented in Italics, followed by specific comments and recommendations in normal text.

1. Performance standards
Provide predictable, stable and increased harvest opportunity.
- *Treaty/Executive Order and non-treaty*
- *C&S obligation*
- *Recreation (consumptive and non-consumptive)*
- *Apply Scientific Review Team (SRT) Guideline (G)171*

The focus of this standard is much too narrow for application throughout the Columbia basin. For example, the focus of many programs (ie. Redfish Lake sockeye captive brood) is conservation. This standard might be more appropriately addressed by listing a variety of potential hatchery uses such as conservation, augmentation, or research and providing indicators commensurate with the goal(s) of the various programs.

1. Performance indicators
Predictable, stable, and increased harvest opportunities met. Managed for increasing, stable, or decreasing trend line, comparing past trend with future. Developed RM&E plan by species to measure and collect data. Evaluated juvenile, smolt to adult survival or contribution to harvest trends.

1. Anadromous

a. Recreational; Increased number of angler days and harvest
- *Catch/unit effort/year*
- *Catch #'s/harvest/year*
- *Units of effort/year*
- *Established baseline at Year One, compare with 5 year survey or one generation*

b. Commercial; Tribal treaty and non-treaty fishery harvest needs met.
- *Deviations from 50% of the ocean and river fishery for fall chinook and steelhead allocation, and other specific determined by species*

This criterion is unclear.

- *Report annually on deviation from 50% allocation of all fisheries, Tribal and Non-Tribal hatcheries above Bonneville*
- *Absolute # harvested*
  - *(a) all fisheries (ocean, in-river)*
  - *(b) Tribal fisheries (ocean, in-river)*

- Number of pounds and value (quantity) harvested

The Columbia River Compact and the Pacific Salmon Commission typically address allocation. Harvest allocation is not a useful performance indicator for individual hatchery projects. Further some programs may be effected in "mixed stock" fisheries more than others (consider ocean harvest of spring versus fall chinook salmon).

2. Resident (native or non-native)

a. Recreational; Tribal Treaty / Executive Order and Non-Treaty fishery. Key statistic is increasing number of angler days to be able to harvest fish with as little effort as possible. Indicators measured should be population specific by species

- Numbers, length, weight, age, and pounds harvested or released
- Deviations from 50% harvest allocation
- Area and time of harvest
- Production cost of hatchery fish harvested
- Deviation from sport minimum threshold by species

This indicator is unclear.

- Perceived value of fish harvested

Due to the variance expected in perceived value, this may not be a realistic or useful measure.

- Angler satisfaction determined every 5 years or after one generation
- Condition factor of fish in creel
- Catch per unit effort goals

3. Complied, where applicable, with HGMP

2. Performance Standard
Conservation of genetic and life history diversity

- Establish baseline for hatchery and/or wild populations
- similar to wild or
- isolated from wild

If isolated from the wild stock, goals of the program probably do not include maintenance of life history and genetic characteristics.

- Evaluate at yearly increments depending upon generation time for the selected species
- Make changes to correct for divergence from baseline
- Apply SRT; G1-2, 4-17

2. Performance Indicators

A. Used number of adults necessary to achieve minimum effective population size (MEPS). Trend target in 4 out of 5 years + 10%

This is an appropriate indicator, however in some locations maintaining MEPS may be an impossible proposition for several generations, since many hatchery programs are initiated following severe declines in abundance. Perhaps displaying an increasing trend toward MEPS would be more appropriate and widely applicable.

B. Evaluated whether life history characteristics were maintained by comparing baseline at year 1 with 5 year survey, or after one generation. Life history characteristics measured:

1. *Age composition*
2. *Fecundity (#, and size)*
3. *Body size (size, length, weight, age, and maturity index)*
4. *Sex ratio*
5. *Juvenile migration timing*
6. *Adult run timing*
7. *Distribution and straying*
8. *Time and location of spawning*
9. *Food habits*

In theory these life-history indicators would be a useful measure of the success of a hatchery program in maintaining genetic and life history traits present in a wild population, however given the large scale declines in abundance, changes in life history traits may not be unexpected. For example, Wohlfarth (1993) suggests that rapid environmental change coupled with severe declines in population size likely result in wild stocks that may not be optimally adapted to natural conditions. Therefore, as population size increases, and life-history and genetic diversity increase, natural selection acting within the increased variation may result in divergence from historical fecundity, run-timing, and other traits as the stock "naturalizes" to current conditions. Simply stated, the historical mean of many life-history traits may not be adaptive in the current altered environment. Changes in genetic and life-history traits may not, therefore be a reliable indicator of detrimental hatchery effects.

C. Evaluated broodstock genetically in year 1 and compare after 5 years, or one generation, in terms of DNA or allozyme profile

D. Captive broodstock

1. *Increased number of individuals in captivity to substantially greater numbers than wild survival standard (% survival standard)*
2. *Progeny represented full range of life history traits of parent population in the wild. Surrogate: genetic analysis (DNA or allozyme frequencies)*

This may not be an affordable or realistic goal. For example, to detect a difference within 0.3 standard deviations of the mean requires approximately 300 samples from each group (Hard 1995). Assuming a $50.00/sample mean cost, this would require about $30,000.00/year in lab fees alone on a per project basis. Further, changes in allelic frequencies will not yield data regarding the representation of wild life-history traits within the hatchery product. Genetic variation measured by allozyme allele frequencies, and most DNA assays (with the exception of quantitative trait loci) is neutral variation, not fitness-related in the sense of life-history traits.

3. Implemented RM&E plan to document survival of juveniles and returning adults

4. Followed NMFS interim standards for captive broodstock

E. Cryopreservation

1. Implemented RM&E plan to represent full range of life history traits (see Risk A10, 1-9)

2. Equaled or exceeded quality control standard for sperm viability

F. Promoted regional gene bank to preserve existing populations not under threat of extinction

G. Complied, where applicable, with HGMP

H. Relevant APR-SRT guidelines evaluated and implemented

3. Performance Standard
Enhance tribal, local, state, regional and national economies

Similar to performance standard one, many hatchery activities are not intended to provide harvest. Therefore, this standard is not applicable to all hatchery programs.

3. Performance Indicators

A. Established increasing trend in the value of harvest by documenting:

1. Commercial and sport fisheries value

2. Economic return from ex vessel, wholesale value

3. Opportunity or angler days translated to dollars

4. Cannot value tribal fisheries only in dollar terms for the commercial and sport fishery

How is this applicable as an indicator?

5. Production cost of hatchery fish harvested

B. Developed overall economic impact model to compute direct, indirect and induced effects from hatchery production.

This indicator is unclear.

4. Performance Standard
Fulfill legal/policy obligations

4. Performance Indicators

A. Legal and policy obligations of the hatchery goal met, in terms of numbers of hatchery fish to the fishery in 4 out of 5 years + 10%

1. Marine and freshwater fisheries

2. Resident fisheries in pounds of fish harvested

B. Decreased litigation

5. Performance Standard
Contribution of hatchery fish carcasses to ecosystem function by subbasin and by hatchery

-Stream/river nutrification from hatchery carcasses
-Nutrient input for fisheries and wildlife
-Food web impacts

5. Performance Indicator

A. Hatcheries developed RM&E plans with stringent disease standards as identified by PNWFHPC and IHOT protocols for using the carcasses as a nutrient source

1. *Collaborative agency, tribal and university research implemented a pilot project*

6. Performance Standard
Provide fish to satisfy legally mandated harvest in a manner which eliminates impacts on weak hatchery and broodstock wild populations
- Apply SRT; G17
APR-SRT G17 does not specifically deal with the issue of mixed stock/selective harvest.
6. Performance Indicators

A. Developed harvest management plan for hatchery fish
B. Computed ratio of wild fish to harvest

1. Evaluated trend analysis of past/present hatchery contributions to harvest.
2. Defined an upper maximum ratio of wild fish allowed in the harvest

C. Documented total harvest of hatchery fish

1. *Used appropriate techniques of selective harvest and rearing by separation in time, space, gear and hatchery fish identification, where appropriate*

D. Determined that total harvest of wild populations of concern does not exceed upper maximum of absolute number of wild fish

This indicator is unclear.

E. Established and met natural population escapement goal, where applicable, in 4 out of 5 years ± 10 %

In the short-term this may be an unrealistic goal, and its validity will be determined by how the natural escapement goal is formulated.

F. Hatchery broodstock goals and objectives established and met in 4 out of 5 years ± 10%
G. Complied, where applicable, with HGMP
H. Relevant APR-SRT guidelines evaluated and implemented

7. Performance Standard
Will achieve within hatchery performance standards
- Apply SRT; G1-2, 4-13, 16, 19

7. Performance Indicators

A. IHOT standards achieved
B. Relevant APR-SRT guidelines evaluated and implemented
C. Complied, where applicable, with HGMP

8. Performance Standard
Restore and create viable naturally spawning populations
- Apply SRT – G1-2, G4-16

While we agree that this should be the goal of salmonid management, this is not a viable goal for a hatchery activity alone. If a wild population exhibits a negative growth trend before a hatchery is constructed, and the factors resulting in the decline of the wild population are not addressed, the wild stock will continue to display negative growth regardless of hatchery operation.

8. Performance Indicators

A. Managed for increasing trend of redd counts as index of natural spawning
B. Managed for increasing numbers of adult fish
C. Managed for increasing trend in adult resident fish
D. Managed for increasing trend in juvenile anadromous or resident fish rearing densities in #'s/m2 by habitat
E. Managed for increasing trend in nutrients from adult carcasses in tributaries
F. Managed for increasing F2 spawners
G. Complied, where applicable, with HGMP
H. Relevant APR-SRT guidelines evaluated and implemented

9. Performance Standard
Plan and provide fish with coordinated mainstem passage and habitat research in the Columbia Basin
- Apply SRT; G17

9. Performance Indicator

A. Developed a project with a regional perspective for a multi-year funded research plan with funding support

This indicator is unclear, and does not address the performance standard.

B. Described funding umbrella to provide context for individual project research

This indicator is unclear, and does not address the performance standard.

C. Developed plan consistent with subbasin goals, objectives and strategies, including Mainstem

As currently constructed, many of the mainstem impacts to salmon may not be considered, by virtue of limitations imposed by the province boundaries. It is therefore unclear how to reconcile passage problems experienced in the mainstem with specific subbasin plans.

10. Performance Standard
Conduct within hatchery research, improve the performance or cost effectiveness of artificial production hatcheries to address the other four purposes
- Apply SRT; G1-2, 4-13, 15-17

What are "the other four purposes" alluded to in this indicator?

10 Performance Indicators

A. Developed comprehensive regionally coordinated RM&E plan that includes a website for all hatcheries in the basin

1. Bonneville Power Administration, National Marine Fisheries Service, United State Geological Survey/Biological Research Division, Federal Energy Regulatory Commission, universities, private aquaculture industry, utilities, states, tribes, land management agencies, etc.

B. Developed a research study plan which:

1. Implemented genetic studies of straying, introgression, and outbreeding depression at a specific hatchery by species
2. Conducted focused carrying capacity study
3. Evaluated potential hatchery/wild competition by ecosystem
4. Evaluated the fate of hatchery population mimicking the wild population in terms of adult return or yield to the creel
This is an unclear objective.
5. Conducted hatchery evaluations on selected hatcheries within eco-systems to estimate post-release survival by tributary, mainstem, estuary, and ocean in order to accurately evaluate hatchery performance by species by hatchery

C. Integrated hatchery and programs into subbasin management plan within 3 years using:

1. Hatchery Genetic Management Plan (HGMP) as part of the plan by species
2. RM&E plan
3. Hatchery specific harvest management plan

D. Improved marine survival and yield of adults in the fishery or spawning grounds

Marine survival *per se* is not a variable that can be controlled by changing hatchery practices.

E. Research priorities have been set by evaluating performance indicators which haven't been met. Standard is adaptive management

11. Performance Standard
Minimize management, administrative and overhead costs.
- *Reduce process*
- *Respond to performance indicators*
- *Conduct annual performance review*
- *Reduced manpower / overhead rates*

Given the mandate of this program to include comprehensive RM&E, annual reports, and accessible databases, manpower would be expected to increase, as well as the associated increases in overhead.

- *Integrate with other programs*
- *Apply SRT; G19*

11. Performance Indicators
A. Managed the process to accomplish declining expenditures for administrative overhead
B. Achieved annual budgeting based on a results-oriented, performance-based management framework
C. Annual reports addressed
1. Program performance based on indicators
2. Consistency with Columbia River Fish Management Plan (CRFMP) production reports
D. IHOT audits conducted as scheduled and results integrated into future funding and program decisions
E. Implementation of IHOT policies and procedures and hatcheries documented

12. Performance Standard
Improve performance indicators to better measure performance standards
- *Apply SRT; G18*

12. Performance Indicators
A. Evaluated effectiveness of performance indicators using adaptive management in order to more accurately measure performance through audit process.
B. Relevant APR-SRT guidelines evaluated and implemented

RISKS

1. Performance Standard
Develop harvest management plan to protect weak populations where mixed fisheries exist
- Apply SRT G17

1. Performance Standard

A. Maximum allowable impact to weak populations not exceeded in 4 out of 5 years ±10 %

B. Life history characteristics of weak populations monitored for change from baseline by comparing at year 1 with 5-year survey or after one generation

See previous comments regarding life-history traits.

C. Maintenance of unique life history characteristics evaluated by comparing baseline at year 1 with a 5 year survey, or after one generation. Characteristics measured:

a. Age composition
b. Fecundity (#, and size)
c. Body size (size, length, weight, age, maturity index)
d. Sex ratio
e. Juvenile migration timing
f. Adult run timing
g. Distribution and straying
h. Time and location of spawning
i. Food habits

D. Documented that natural population escapement goal not adversely affected in 4 out of 5 years ± 10 % for specific species and populations

This indicator would benefit from additional clarification, what is intended by ± 10 %?

E. Relevant APR-SRT guidelines evaluated and implemented

2. Performance Standard
Do not exceed carrying capacity of fluvial, lacustrine, estuarine and ocean habitats
- Apply SRT G1-2, G4-13, G17

2. Performance Indicators

A. Developed an appropriate RM&E plan

1. Freshwater

a. Snorkel survey conducted to quantify microhabitat partitioning

b. Emigration rate, growth, food habits, condition factor, and survival rate evaluated

2. Conducted control vs. treatment carrying capacity evaluation

a. estimated #/m 2 by year class by habitat type

The challenge is defining appropriate carrying capacity estimates, which remains a difficult, if not impossible task, for most stocks. In many cases, even the well formulated RM&E plans may be unable to adequately assess the potential carrying capacity of a system, given the tremendous variability of environmental conditions.

B. Reservoir, estuarine, and ocean research, monitoring, and evaluation plan developed; implemented ISRP recommendation to define monitoring and evaluation research approach
C. Relevant APR-SRT guidelines evaluated and implemented

3. Performance Standard
Assess detrimental genetic impacts among hatchery vs. wild where interaction exists
- Apply SRT G1-2, 4-18

APR-SRT G12 is not consistent with the goal of maintaining natural stock structure. Straying is a life-history trait expressed, to some degree, by all populations, and may be useful for the introduction of new genetic variation, and offsetting the deleterious effects of genetic drift (NMFS 1997).

3. Performance Indicators
A. Initially, it is assumed that stray rate is a surrogate for a thorough and more complex measurement of genetic impact. More specific measurements to be implemented on a selected basis:
1. Experimental design for evaluating genetic impact recommended by ISRP.

Which experimental design, and in which document?

2. Evaluated hatchery population against standard stray rate (<5% non-indigenous populations; <20% indigenous populations; NMFS standard)

This standard has no quantitative basis, and may be too restrictive in some cases.

3. Measured introgression by comparing allele frequencies between hatchery and wild
4. Implemented an appropriate experimental design to quantitatively measure outbreeding depression

The quantitative measure of outbreeding depression requires strict, costly, and long-term studies that are likely outside budgetary constraints for most programs.

5. Conducted RM&E on selected basis at a

specific hatchery and/or on selected species
6. Experimental design for evaluating genetic impact recommended by ISRP.
Which recommendation, from which paper?

B. Implemented HGMP where appropriate.
C. Relevant APR-SRT guidelines evaluated and implemented

4. Performance Standard
Unpredictable egg supply leading to poor programming of hatchery production to maintain Treaty/Executive Order and non-treaty fisheries and broodstock escapement

4. Performance Indicators
A. Achieved percent egg take goal in 4 out of 5 years
B. Achieved MEPS in 4 out of 5 years ± 10 %
C. Implemented PNWFHPC, IHOT disease protocols, and HGMP, where appropriate, in terms of egg transfer to the hatchery

5. Performance Standard
Production cost of program outweighs the benefit
- Apply SRT G18-19

Does cost in this context imply expense or risk? For many programs, the hatchery product does not have a direct monetary value. How would this performance standard be applied to hatcheries that do not produce a harvestable product?

5. Performance Indicators
A. Evaluated trends in the ratio of hatchery juvenile production cost per cost of juvenile production from habitat projects by subbasin by hatchery per adult production

This indicator is unclear.

1. Hatchery production cost is equal to or less than 1 in 4 out of 5 years ± 10 %

This indicator is unclear.

B. Relevant APR-SRT guidelines evaluated and implemented

6. Performance Standard
Cost effectiveness of hatchery ranked lower than other actions in subregion or subbasin
- Apply SRT G19

In practice it may be difficult to objectively apply cost effectiveness as a criterion for comparing different conservation/restoration/augmentation programs. For example, a conservation hatchery designed to maintain the genetic and life-history characteristics of a wild stock will likely produce fewer fish for the same cost as an augmentation facility.

6. Performance Indicators

A. Developed cost effective methods of producing benefits to recreation fishery such as:

1. Cost per angler day

a. Habitat and fish passage compared to hatchery

b. Self-sustaining population compared to continuing artificial production

2. Cost per experience (economic model)

3. Cost per fish harvested in the recreational fishery

B. Achieved highest numerical ratio of returning adults or recovery to healthy viable resident population levels per cost of action (habitat, passage, hatchery)

This indicator needs clarification.

C. Achieved highest ratio of intrinsic social value (satisfaction survey) of returning adults or recovery of healthy viable population levels per cost of action

D. Achieved highest ratio of value of harvest per cost of hatchery by species to the non-treaty commercial fishery

E. Achieved least cost production of behaviorally adapted juveniles complying with NMFS interim standards for captive broodstock

This indicator needs clarification.

F. Relevant APR-SRT guidelines evaluated and implemented

7. Performance Standard

Will not achieve within hatchery performance standards

- Apply SRT G1-2, 4-13, 16, 19

7. Performance Indicators

A. Conducted comparative evaluation of actual within hatchery performance and exceeded or equaled performance standards as enumerated by IHOT

B. Defined resident fish within hatchery performance standards if different from IHOT and equaled or exceeded standard

C. Conducted an audit to determine compliance with IHOT standards

8. Performance Standard

Evaluate habitat use and potential detrimental ecological interactions

- Apply SRT G4-5, 8, 17-18

8. Performance Indicators

A. Selected tributaries by subbasin and hatchery by species (anadromous and resident); conducted comparative evaluation of prestocking population with post stocking after five years or after one generation by measuring some of these parameters:

1. Evaluated emigration rate

a. Anadromous or resident stocked fish and naturally reproducing anadromous or resident population

2. Conducted comparative evaluation of rearing densities (# / m2) by habitat before and after stocking hatchery fish vs. wild fish

3. Computed growth rate, condition factor, and survival of 1a above

4. Evaluated direct intra- and inter-specific competitive interaction between stocked anadromous or resident fish and wild resident fish

5. Conducted snorkel surveys to quantify microhabitat partitioning by species

6. Computed prey composition in diet of 1a above

7. Determined predation rate

a. Fish, birds, marine mammals

B. Implemented tributary RM&E plan by subbasin by specific hatchery by species, and extrapolated to other subbasins and hatcheries in the basin

C. Developed and implemented RM&E plan for reservoir habitat

1. Trophic level disruptions

a. Species and prey population composition before and after stocking

2. Implemented experimental design for specific research applications recommended by ISRP

D. Developed RM&E plan for estuary and near shore marine habitat

1. Implemented experimental design recommended by ISRP

E. Natural habitat improved to double survival by species by specific life history stage within 10 years

F. Implemented HGMP where appropriate

G. Relevant APR-SRT guidelines evaluated and implemented

9. Performance Standard

Avoid disease transfer from hatchery to wild fish and vice versa

- Apply SRT G17, 19

APR-SRT G 17 and 19 do not address disease issues.

9. Performance Indicators

A. Established comparative annual sampling of disease in hatchery and wild populations

B. Complied with IHOT standards and PNWFHPC guidelines
C. Applied disease standards to resident fish rearing and stocking activities, including net pens, acclimation ponds, and direct releases
D. Evaluated incidence of drug resistant pathogens by comparing to baseline in year 1 to survey every five years
E. Implemented HGMP where appropriate
F. Relevant APR-SRT guidelines evaluated and implemented

10. Performance Standard
Evaluate impacts on life history traits of wild and hatchery fish, from harvest and spawning escapement
- Apply SRT G1-15, 18

10. Performance Indicators
A. Tracked trends to evaluate change by comparing a baseline at year 1 with a 5-year survey, or after one generation. Specific life history characteristics measured are:
1. Age distribution
2. Fecundity (#, and size)
3. Body size (length, weight, age, maturity index)
4. Sex ratio
5. Juvenile size and migration timing
6. Adult run timing
7. Distribution and straying
8. Time and location of spawning
9. Food habits

B. Conducted RM&E program on selected hatchery by species and extrapolated to others
C. Implemented experimental design recommended by ISRP
D. Implemented HGMP where appropriate
E. Relevant APR-SRT guidelines evaluated and implemented

11. Performance Standard
Assess survival of captive broodstock progeny vs. wild cohorts
- Apply SRT G1-10, 13-19

11. Performance Indicators
A. Achieved increased survival threshold for captive broodstock over wild adults; Implemented RM&E plan with appropriate experimental design to measure:
1. % survival of viable eggs, fry, and offspring
2. % survival to release
3. Pre-release juvenile quality, equal to or exceeded physiological, morphological, and behavioral threshold compared to wild population

This indicator requires clarification.

4. Achieved post-release criteria in terms of survival, growth, condition factor, and behavioral adaptation

B. Implemented HGMP where appropriate

C. Relevant APR-SRT guidelines evaluated and implemented

12. Performance Standard

Depleting existing population spawning in the wild through broodstock collection

- Apply SRT G8, 10, 12, 15-17

12. Performance Indicators

A. Documented stable or increasing trend of redd counts as index of natural spawning

B. Documented stable or increasing numbers of adult fish.

C. Documented stable or increasing trend in adult resident fish.

D. Documented hatchery spawner to recruit ratio equal to or greater than 1

E. Relevant APR-SRT guidelines evaluated and implemented

As a general comment, the guidelines presented in the APR (NWPPC 1999), recognize and suggest implementation of innovative fish culture techniques. This represents a commendable attempt to increase the rate of hatchery reform, and over the long-term should serve to benefit salmon recovery in the Columbia basin. However, as outlined above, many of the performance indicators associated with the guidelines and performance standards may be too narrowly defined. If the goal of the NWPPC program is to practice adaptive management, perhaps adaptive RM&E should be considered as well. It might be useful to incorporate the flexibility to allow managers to formulate novel strategies for RM&E that specifically address the uncertainties associated with a given project.

The use of IHOT and PNWFHPC protocols is recommended throughout the document. It might be useful to approach these protocols as the best currently available, but allow for change as newer approaches are developed.

Finally, while RM&E is an important aspect of hatchery operations, the potential exists for RM&E activities to consume funds that could be used to put more fish in the water, protect habitat, and implement new projects. One challenge facing the NWPPC will be optimizing the allocation of funds to achieve recovery, rather than document the decline of Columbia basin species.

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